

# इंटरनेट

# मानक

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IS 11999 (2007): Method for determination of plastic strain ratio 'r' for steel metals [MTD 3: Mechanical Testing of Metals]



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भारतीय मानक  
धातुओं की चददर के लिए प्लास्टिक स्ट्रेन  
अनुपात 'आर' ज्ञात करने की पद्धति  
( पहला पुनरीक्षण )

*Indian Standard*

**METHOD FOR DETERMINATION OF PLASTIC  
STRAIN RATIO 'r' FOR SHEET METALS**  
( *First Revision* )

ICS 77.040.10

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**BUREAU OF INDIAN STANDARDS**  
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## NATIONAL FOREWORD

This Indian Standard (First Revision) which is identical with ISO 10113 : 1991 'Metallic materials — Sheet and strip — Determination of plastic strain ratio' issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of the Mechanical Testing of Metals Sectional Committee and approval of the Metallurgical Engineering Division Council.

This standard was originally published in 1987. This revision of the standard has been taken up to align it with ISO 10113 : 1991 by adoption under dual numbering system.

The text of ISO Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

- a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.
- b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their places are listed below along with their degree of equivalence for the editions indicated:

<i>International Standard</i>	<i>Corresponding Indian Standard</i>	<i>Degree of Equivalence</i>
ISO 6892 : 1984 Metallic materials — Tensile testing	IS 1608 : 2005 Metallic materials — Tensile testing at ambient temperature ( <i>third revision</i> )	Technically Equivalent
ISO 7500-1 : 1988 Metallic materials — Verification of static uniaxial testing machines — Part 1 : Tensile testing machines	IS 1828 (Part 1) : 2005 Metallic materials — Verification of static uniaxial testing machines: Part 1 Tension/compression testing machines — Verification of calibration of the force-measuring system ( <i>third revision</i> )	do
ISO 9513 : 1989 Metallic materials — Verification of extensometers used in uniaxial testing	ISO 12872 : 1990 Metallic materials — Verification of extensometers used in uniaxial testing	Identical

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

# Indian Standard

## METHOD FOR DETERMINATION OF PLASTIC STRAIN RATIO 'r' FOR SHEET METALS ( First Revision )

### 1 Scope

This International Standard specifies a method for determining the plastic strain ratio of flat products (sheet and strip) made of metallic materials.

### 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 6892:1984, *Metallic materials — Tensile testing*.

ISO 7500-1:1986, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tensile testing machines*.

ISO 9513:1989, *Metallic materials — Verification of extensometers used in uniaxial testing*.

### 3 Definitions

For the purposes of this International Standard, the following definitions apply.

**3.1 plastic strain ratio,  $r$ :** The ratio of the true width strain and true thickness strain in a test piece that has been submitted to uniaxial tensile stress:

$$r = \frac{\epsilon_b}{\epsilon_a}$$

where

$\epsilon_a$  is the true thickness strain;

$\epsilon_b$  is the true width strain.

The above expression is only valid in the region where the plastic strain is homogeneous.

Since it is easier to measure changes in length than changes in thickness, the following relationship derived from the law of constancy of volume before and after plastic strain is used to calculate the plastic strain ratio  $r$ :

$$r = \frac{\ln\left(\frac{b_0}{b}\right)}{\ln\left(\frac{Lb}{L_0b_0}\right)}$$

In addition to the calculated value of  $r$ , the orientation of the test piece relative to the rolling direction, as well as the strain level, shall be stated. For example:  $r_{45/20}$  (see table 1).

For some materials exhibiting a phase change during plastic deformation, the volume of the measured section cannot always be assumed constant. In such cases, the formula to be applied shall be agreed, prior to testing, between the interested parties and shall be stated in the test report.

**3.2 weighted average plastic strain ratio,  $\bar{r}$ :** The weighted average of the  $r_{x/y}$  values for different test piece orientations, calculated using the formula

$$\bar{r} = \frac{r_0 + r_{90} + 2r_{45}}{4}$$

**3.3 degree of planar anisotropy,  $\Delta r$ :** A coefficient calculated using the formula

$$\Delta r = \frac{1}{2} (r_0 + r_{90} - 2r_{45})$$

For some materials, other test piece orientations may be chosen, in which case formulae other than those given in 3.2 and 3.3 will have to be used. These formulae shall be given in the test report.

## 4 Symbols

The meanings of the symbols used in this International Standard are given in table 1.

Table 1

Symbol	Meaning	Unit
$b_0$	Original gauge width of the test piece	mm
$b$	Gauge width of the test piece after straining to a specified elongation	mm
$L_0$	Original gauge length	mm
$L$	Gauge length after straining to a specified elongation	mm
$r$	Plastic strain ratio	—
$r_{x/y}$	Plastic strain ratio in x-direction (in degrees) relative to the rolling direction at a strain level of y %	—
$\bar{r}$ 1)	Weighted average of $r_{x/y}$ values	—
$\Delta r$	Degree of planar anisotropy	—
$\epsilon_a$	True thickness strain	—
$\epsilon_b$	True width strain	—

1) In some countries  $r_m$  is used instead of  $\bar{r}$ .

## 5 Principle

A test piece is subjected to a tensile test to a specified strain level and the plastic strain ratio  $r$  calculated from measurements of the changes in length and width. The orientation of the test piece relative to the rolling direction, and the strain level for which the values of  $r$  are determined, are as specified in the relevant product standard.

## 6 Test equipment

The tensile testing machine used shall comply with the requirements of ISO 6892 and ISO 7500-1.

The device(s) used for determining the changes in gauge length and gauge width shall be capable of measuring to within  $\pm 0,01$  mm and  $\pm 0,005$  mm, respectively.

Where extensometers are used, they shall be class 1, as defined in ISO 9513, or better.

The method of gripping the test piece shall be as specified in ISO 6892.

## 7 Test piece

7.1 The test piece shall be obtained in accordance with the requirements of the relevant product standard or, if not specified therein, as agreed between the interested parties.

The type of test piece and its preparation, including the machining tolerances, the tolerances on shape and the marking of the original gauge length, shall be as defined in ISO 6892, but within the gauge length the edges shall be sufficiently close to parallel for no two width measurements to differ by more than 0,1 % of the mean of all the width measurements.

7.2 The test piece thickness shall be the full sheet thickness unless otherwise specified.

7.3 The surface of the test piece shall not be damaged by scratches, etc.

## 8 Procedure

8.1 The test is normally carried out at ambient temperature between 10 °C and 35 °C. Tests carried out under controlled conditions shall be made at a temperature of  $23 \text{ °C} \pm 5 \text{ °C}$ .

8.2 If the strain measurements are made manually, the original width of the test piece shall be measured at least at three points evenly distributed along the gauge length, including one measurement at each end of the gauge length. The mean value of these width measurements shall be used in calculating the plastic strain ratio.

8.3 If the measurements are made automatically, the original gauge length and the width at least at one measurement point shall be measured using an extensometer of class 1, as defined in ISO 9513, or better.

8.4 The test speed, i.e. the speed of separation of the crossheads of the machine, shall not exceed

50 % of  $L_c$  per minute

where  $L_c$  is the length of the parallel-sided portion of the test piece.

8.5 Mount the test piece in the grips of the testing machine and, keeping the test speed within the limit specified in 8.4,

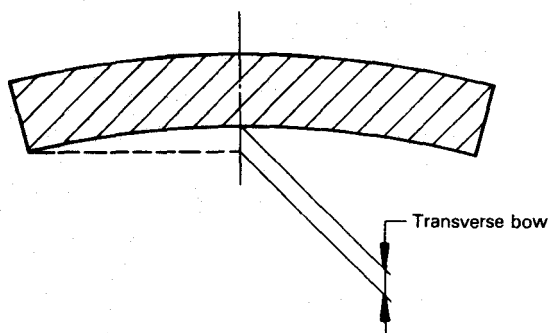
a) either apply the force required to achieve the strain level specified in the relevant product standard (manual determination),

b) or apply the force required to determine width values at the strain level specified in the relevant product standard (automatic determination).

**8.6** In the case of manual determination, after removing the force measure the gauge length  $L$  and gauge width  $b$  in the same manner and to the same tolerances as for the original gauge length and original gauge width.

**8.7** In the case of automatic determination, the measurements of length and width at the specified strain level shall be made using an extensometer as specified in clause 6.

**8.8** If the test piece shows any transverse bow (see figure 1), which could influence the test results, the test shall be considered invalid and a new test shall be carried out.



**Figure 1 — Transverse bow in a test piece**

**8.9** If the plastic strain is not homogeneous, the test results shall be considered invalid and a new test shall be carried out.

## 9 Expression of results

**9.1** For a manual determination, calculate the plastic strain ratio, the weighted average of the plastic strain ratio for different test piece orientations, and the degree of planar anisotropy using the formulae given in 3.1, 3.2 and 3.3.

**9.2** For an automatic determination, the automatic tensile testing machine and data processing programme give the plastic strain ratio, the weighted average of the plastic strain ratio for different test piece orientations, and the degree of planar anisotropy directly.

**9.3** The calculated values of the plastic strain ratio shall be reported to the nearest 0,05.

**9.4** Manual and automatic determinations may give different results. In the case of significant differences, the manual determination shall be considered the reference method.

## 10 Test report

The test report shall include the following information:

- a) a reference to this International Standard;
- b) identification of material tested;
- c) the method used (manual or automatic);
- d) the type of test piece used;
- e) the orientation of the test piece relative to the rolling direction;
- f) the strain level at which the measurements were made;
- g) the test results;
- h) the formulae used to calculate  $\bar{r}$  and  $\Delta r$  if different from the formulae given in 3.2 and 3.3.



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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards: Monthly Additions'.

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